Heights of rivers above zeros of gauges—Continued.

Stations.	Distance to mouth of river.	Danger line on gauge.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
Ouachita River.	*Miles.*	*Feet.*	*Feet.*		*Feet.*		*Feet.*	*Feet.*
Camden, Ark	340	39	2.6	11-17	2.4	19-30	2.5	0.2
Monroe, La	100	40	0.0	1-31	0.0	1-31	0.0	0.0
Yazoo River.								
Yazoo City, Miss	80	25	— 2.4	12-14	— 2.7	2-4, 31	—2.6	0.3
Chattahoochee River.								
Columbus, Ga	140	20	0.1	24-27	— 1.5	10-12, 16	—0.8	1.6
Flint River.								
Albany, Ga	80	20	1.7	4	0.8	12, 28	1.2	0.9
Cape Fear River.								
Fayetteville, N. C	100	38	2.2	27	0.2	8, 9	0.9	2.0
Columbia River.								
Umatilla, Oreg	270	25	2.8	23, 24	2.1	31	2.6	0.7
The Dalles, Oreg	166	40	4.9	9	2.8	31	4.0	2.1
Willamette River.								
Albany, Oreg	99	20	2.5	26	1.0	1-19	1.2	1.5
Portland, Oreg	10	15	3.2	29	0.4	21	2.0	2.8
Edisto River.								
Edisto, S. C	75	6	4.8	1, 2	2.6	12, 13	3.6	2.2
James River.								
Lynchburg, Va	257	18	0.4	24	— 0.2	1-11	0.0	0.6
Richmond, Va	110	12	1.0	27	— 0.3	4-14	0.0	1.3
Alabama River.								
Montgomery, Ala	265	35	— 0.2	19	— 1.5	6-16	—1.2	1.3
Selma, Ala	212	35	— 0.8	21	— 2.0	1-19	—1.8	1.2
Coosa River.								
Gadsden, Ala	144	18	— 0.3	21-26	— 0.8	2-11	—0.6	0.5
Tombigbee River.								
Columbus, Miss	285	33	— 3.2	12	— 3.7	28-30	—3.6	0.5
Demopolis, Ala	155	35	— 2.4	1-6	— 2.6	13-31	—2.5	0.2
Black Warrior River.								
Tuscaloosa, Ala	90	38	— 1.6	1, 23-31	— 1.9	6, 9-21	—1.8	0.3
Pedee River.								
Cheraw, S. C	145	27	11.2	14	0.3	12	1.5	10.9
Black River.								
Kingstree, S. C	60	12	3.6	31	1.0	15-18	2.2	2.6
Lumber River.								
Fairbluff, N. C	10	6	0.5	31	— 0.8	11-13	—0.2	1.3
Lynch Creek.								
Effingham, S. C	35	12	3.7	26	2.1	7-13	2.6	1.6
Potomac River.								
Harpers Ferry, W. Va	170	16	0.4	26-28	0.0	4-24	0.1	0.4
Roanoke River.								
Clarksville, Va	155	12	0.3	20, 29	— 0.1	5-11	0.1	0.4
Sacramento River.								
Redbluff, Cal	241	23	1.2	23	0.0	1, 10, 11	0.4	1.2
Sacramento, Cal	70	25	10.0	25, 26	8.3	1-3	8.8	1.7
Santee River.								
St. Stephens, S. C	50	12	6.5	18	— 1.3	9, 10	1.8	7.8
Congaree River.								
Columbia, S. C	37	15	3.5	14	1.5	1-12, 16-20, 24-31	1.7	2.0
Wateree River.								
Camden, S. C	45	24	12.4	14	1.6	10	3.7	10.8
Savannah River.								
Augusta, Ga	130	32	8.5	14	3.9	11	5.5	4.6
Susquehanna River.								
Wilkesbarre, Pa	178	14	0.0	1-31	0.0	1-31	0.0	0.0
Harrisburg, Pa	70	17	1.8	1	0.5	21	0.9	1.3
Juniata River.								
Huntingdon, Pa	80	24	3.0	26	2.8	1-25, 28-31	2.8	0.2
W. Br. of Susquehanna.								
Williamsport, Pa	35	20	0.9	1, 2	0.3	9-12, 18-20	0.5	0.6
Waccamaw River.								
Conway, S. C	40	7	2.7	21	1.1	14, 15	1.9	1.6

*Distance to Gulf of Mexico.

SPECIAL CONTRIBUTIONS.

WINDS AND CLOUDS.

By Professor BRILLOUIN of the École Normale Supérieure, Paris.

[Translated from the Annales de Chimie et de Physique, October, 1897, pp. 145–153, and Ciel et Terre, October 16, 1897, pp. 393–399. Communicated as a summary of a more elaborate memoir that will be published in the Annals for 1898 of the Central Meteorological Bureau of France.—C. A.]

After having for a long time devoted their efforts to the study of atmospheric pressure, meteorologists have now turned their attention to the clouds; they photograph them and endeavor above all to record the heights of the various types. The description of the forms and their relations to meteorology in general has made but very little progress because in most of the recent treatises the chapters relating to the clouds have been restricted to the enumeration of the different types adopted by the international conferences without any further indications.[1] Some treatises are even more positive, and formally declare that up to this time it has not been possible to make any use of the aspect of the sky for forecasting the weather;[2] this is probably true of the central offices of the weather services on account of the insufficiency of the short telegraphic dispatches, but is quite the reverse when we consider the experience of an isolated observer.[3] The appearance of the sky suffices to show what is passing at a distance of at least 100 or 200 kilometers from any station, but the experience acquired is personal because it is synthetical. This is affirmed even by those who have bestowed the most labor on this subject, e. g., Clement Ley[1] from a narrow point of view; Abercromby[2] with more independence of thought. It appears then that theory alone should be capable of defining absolutely consistent types, and of analyzing and describing all their characteristics. Unfortunately, until within recent years, theory has dealt only with two kinds of action capable of producing condensation,[3] viz, the expansion to which we owe the cumulus clouds, and the cooling by radiation which produces the stratus clouds; these two forms which are characteristic of permanent conditions are, therefore, useless, or nearly so, for forecasting.

The transient forms which correspond to the changes of weather are due to the mixtures of air from contiguous regions, one of which is calm and the other is in movement; but the theory of these clouds due to mixture has hitherto been unapproachable. At first, the physical theory of condensation by mixture was so complex, from an analytical

[1] Lancaster remarks that this opinion, which was true ten years ago, is no longer so to-day. The investigations into the forms of clouds and the relations of these to the various atmospheric conditions are now carried on everywhere with great activity, and very important works on this subject have been recently published. Among the most recent and most interesting we mention the beautiful memoir of Mr. H. Helm Clayton, "Discussion of the Cloud Observations made at the Blue Hill Observatory," which forms the fourth part of Volume XXX of the Annals of the Astronomical Observatory of Harvard College, Cambridge, Mass. This memoir is accompanied by numerous plates, and contains more than 200 quarto pages.

[2] Van Bebber. Handbuch der ausübenden Witterungskunde, 2 vols., 1886. Die Wettervorhersage, 1 vol., 1891, pp. 50.

[3] The upper and lower clouds were elaborately observed and telegraphed for the use of the daily weather bulletin of the Cincinnati Observatory, beginning with September, 1869, and have also been telegraphed and shown on the tridaily charts of the Signal Service and Weather Bureau ever since July, 1871. They have often proved of great importance in making up the weather forecasts.—C. A.

[1] Modern Meteorology (1878). Fourth Conference. Clouds and Weather Signs, by Cl. Ley, pp. 102–136. Aids to the Study and Forecast of the Weather, 1880. Cloudland, 1891, 1 vol.

Unfortunately Ley ascribes everything to the "cyclones" of the temperate regions. A glance at his illustrations will show that we have to do, not with the coordination around a center, but with two contiguous currents which interfere with each other and are equivalent to the sketch given farther on. Ley's diagram is simply reproduced by Sprung in his Lehrbuch der Meteorologie, 1885.

[2] Weather: A Popular Exposition of the Nature of Weather Changes from Day to Day, by the Hon. Ralph Abercromby (3d edition), 1892. 1 vol., London. Tropical and Extratropical Cyclones (Proc. of the Royal Society of London, Vol. XLIII, 1887, pp. 1–30). This article was written on his return from a meteorological journey around the world. In the two pages of "Conclusions" the author admirably describes the difference between the storms of our latitudes and those of the tropics; the last phrase, which gives more importance to the analogies than to the differences, is the only part that is ordinarily quoted.

[3] It should perhaps be said that the older theory of mixtures was equally prominent until Espy and Hann forced it into the background. (See Hann's Memoirs, translated by the Editor, in the Ann. Rep. Smithsonian Inst., 1877.)—C. A.

point of view, that no descriptive enumeration of the various possible cases could be attempted; this gap has been filled by the several memoirs of Professor von Bezold[1] and the methods for detailed graphic discussion that he invented; this suffices for the study of mixtures in calm weather, but these mixtures are of little activity and of little interest. As to the mixtures produced by different or opposing contiguous winds, not only was it not known how to study them, but the theory of the general circulation of the atmosphere systematically ignored them. Up to the time of the publication of the fundamental memoir by von Helmholtz,[2] which, in spite of the authority of this eminent physicist, passed unnoticed[3] all the attempts to frame a theory of the general circulation embraced the atmosphere of the globe as a whole.

The continuity of the general movements, which is only an arbitrary hypothesis, was, and still is, regarded by the greater number of theoretical students as an axiom that is so self-evident that it is useless to enunciate it;[4] now it is precisely the opposite to this that is in evidence and that results from daily observation. The atmosphere is divided into regions having different characteristics as to temperature, cloudiness, and velocity of the wind, which are separated by zones often very insignificant but permanent when they follow the coast line of continents and oceans. These discontinuities are by no means incompatible with the aerodynamic theory; quite the contrary; in an ideal fluid that is nonconductive as to heat and has no internal friction there is no condition of continuity attached to the distribution of the temperatures. Only two conditions of continuity are imposed upon the velocities, i. e., that of the conservation of matter and that of the continuity of pressure,[5] but not the continuity of the derivatives of pressure, viz, the gradients. Any different winds whatever may exist on the two sides of a surface of separation. Aerodynamics will teach us what forms and what movements this surface of separation may assume.

Continuity of temperature and of velocity is imposed only in a single case: that in which numerous causes of local disturbances, small and alternating, and averaging zero, produce a large number of restricted and slow circulations throughout the whole zone. In this case the transportation of matter, with its thermic and dynamic properties, produces a general continuous state *by convection;* this is illustrated by the average condition produced in extended zones by the alternations of day and night. In the terrestrial atmosphere the conductivity, the internal friction, and the diffusibility are so very small that *in the absence* of mixtures it would require centuries of time for the penetration of motion, or of heat, or of aqueous vapor, to only a few tens of meters from a surface of initial discontinuity, as Helmholtz has reminded us[6] in the beginning of the above-mentioned memoir.

[1] Sitzungsb. der Berliner Kon. Akad., 1888. (Translation in Abbe's Mechanics of the Earth's Atmosphere.)

[2] Sitzungsb. Kon. Akad., Berlin, 1888–89.

[3] This memoir is well known to the majority of meteorologists in Germany, England, and America. It is summarized in Waldo's Modern Meteorology, and is given in full in the Editor's collection of translations published by the Smithsonian Institution as the Mechanics of the Earth's Atmosphere.—C. A.

[4] The discontinuous phenomena of the general circulation have been dwelt on by Ferrel, Margules, Teisserenc de Bort, Rausenberger, and others.—C. A.

[5] That is, the continuity of pressure in the case of movements that are propagated slowly. Discontinuities of pressure are possible, but they are propagated with the velocity of sound and play no role in the general circulation, however much they may influence certain special phenomena.

[6] In order, by the influence of viscosity, to reduce by one-half the difference of velocity at the soil and at the upper surface of the atmosphere, supposed to be homogeneous and 8 kilometers deep, forty-three thousand years would be required. In order to reduce the difference of temperature by one-half by the process of conduction of heat thirty-six thousand years would be required.

Thus, the whole theory of the movements of the atmosphere becomes essentially that of the subdivision of the atmosphere into distinct convective zones (areas of high pressure, the anticyclones of the meteorologists or the regions of calms of M. Duclaux) and that of the permanence, or the gradual, or the instantaneous transformation of the surfaces of these convective zones. This subdivision, moreover, is theoretically inevitable, since in an annular zone in a state of average convection, the motion obeys the law of the areas; in this case the velocity of the wind varies in an inverse ratio to its distance from the axis of rotation. These velocities would become formidable in a zone of small extent in latitude did they not produce spontaneously a mechanism of energetic resistance. This consists in the mixtures of contiguous zones, produced either by the inequalities of the ground or by the inequalities of density which regulate the movement and moderate the velocity of the wind. This mechanism, however, does not act uniformly throughout the whole extent of the atmosphere, since neither is the soil uniformly undulating, nor is the atmosphere uniformly cloudy. The plains and the mountains, the continents and the seas, give rise to natural zones whose properties are diverse and indicate the natural position of the surfaces of separation.

In the memoir already alluded to Helmholtz has investigated, by analytical methods, the form of the separating surfaces of annular zones surrounding the whole globe and the position occupied by the ring of mixture between the two zones which produce it, but he has restricted himself to the case of dry air which leads to very simple results.

The combined study of these two memoirs, one by von Bezold, the other by von Helmholtz, has enabled me to study and describe every form of cloud characteristic of contiguous, stable, cloudy zones, as also the changes, either slow or rapid, that accompany them, and the encroachments inversely below and above in the atmosphere (the derived currents and the interpolated layers of M. Duclaux) which necessarily result from certain distributions of temperature and cloud.

I had first to complete von Bezold's theory of mixtures by insisting on the fact that a mixture of cloudy air and of clear air, containing but little moisture, is always accompanied by a fall of temperature produced by the partial evaporation and that for certain proportions the mixture is colder[1] than the colder of the two components. The mixture is, therefore, also denser, and falls downward between the two components under the form of a "very cold wave," being clear if the evaporation is complete but foggy if the evaporation is not completed.

On the contrary, two saturated components always give a feebly cloudy mixture of intermediate temperature, but a little above the mean of the component temperatures these thin clouds are feebly ascendant in calm weather.

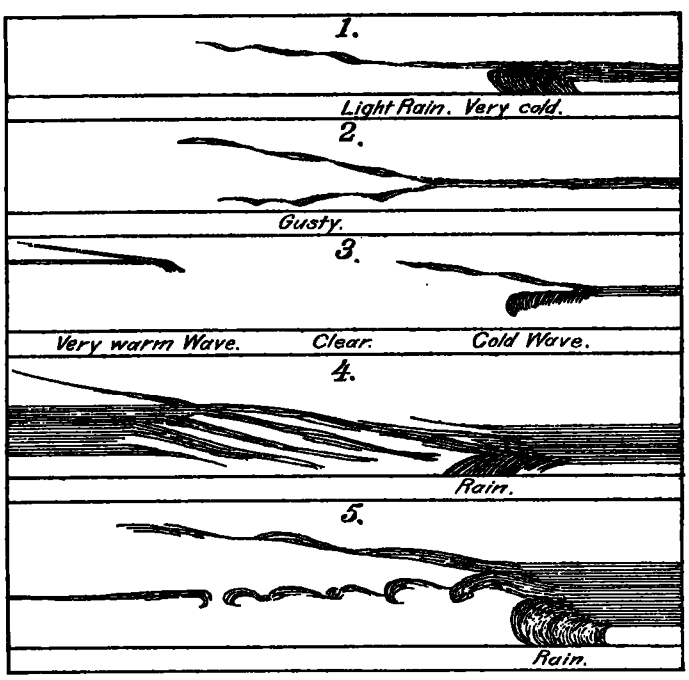
Taking up the theory of Helmholtz under an elementary geometric form, I have given a simple exposition of it, and have developed the discussion of the form and of the stability of the surfaces of separation of two regions having unequal cloudiness and animated by different winds, and have traced outline sections of the bands, together with their systems of clouds, formed where these two zones intermix, one ascending and the other descending, and have indicated the cases in which the resulting rain will fall in showers or continuously, and on the contrary, the cases in which the sky will clear up and the appearances it will present.

I will at present limit myself to indicating the essential points of this study. First, when one desires to study the movements of the atmosphere with respect to the rotating terrestrial globe, it is necessary to take account, not only of the real forces, but of the apparent forces, such as the simple

[1] Von Bezold, 3d Memoir, October, 1889, art. c., translation in Mechanics of the Earth's Atmosphere, p. 274.

and composite centrifugal forces, which are due to the mobility of the reference axes. Two equal masses animated by different movements are, in the case of rotation, not subject to equal forces. In a convective zone (viz, where motion exists) the level surfaces are not parallel to the surface of quiet water; they are more concave toward the center of the globe. Pressure diminishes slowly from the center of such a zone toward its boundaries.

The surface of separation between two zones is the locus of the mutual intersections of level surfaces having the same numerical designation in the two zones [viz, the place of intersection of the equivalent contour lines in the two zones.—C. A.]. This surface can have any inclination whatever to the horizon; it is parallel to the axis of rotation of the earth if the densities are equal, although the velocities may be different. Two conditions are necessary for stability; one of these I shall call *thermic*, the other *dynamic*. The thermic condition requires that in going from the ground upward in the direction of the pole, but not in the direction of the vertical, one shall meet layers of air of decreasing density; the dynamic condition is that the velocity of the wind toward the east shall decrease as we traverse horizontally over the discontinuous surface (the surface of separation) in the direction of increasing latitude. In a ring of mixture [i.e., the belt along a small circle of latitude between the northern and southern components.—C. A.], where the relative proportion of the two components varies progressively, the dynamic condition is that the velocity of the wind toward the east shall increase less rapidly as we go from south to north than in a homogeneous ring in convective equilibrium.



The left hand side of this diagram is the polar side: Cold above, wind from the east.

The right hand side is the equatorial side: Warm above, wind from the west.

As to the position of the mixture, higher or lower in the atmosphere, this also depends upon two conditions, one thermic and the other dynamic. In the case of mixtures of two zones of dry air, the dynamic condition has a preponderating influence, since the specific volume of the mixture is then equal to the average of the specific volumes of the components; but this is not the case when there is any condensation, and especially when there is any evaporation, to even a limited amount. From this there results, at different altitudes, on the surface of separation of two unequally cloudy zones certain tendencies, sometimes concordant, but unequal, sometimes opposed to each other, to which I have devoted a somewhat minute discussion. The preceding figure represents an outline section of the five most important cases and explains itself.

During the many years that I have studied the sky, I have very frequently observed, in all their purity, the more typical forms of clouds in continuous zones occupying the whole sky. It was the almost complete absence of these forms from the International Cloud Atlas and the evident insufficiency of the descriptions in that atlas which, by exciting my curiosity, led me to undertake to study their theory. Hereafter, excepting any errors that I may have made in this study, the signification of any given aspect of the sky will be associated with a perfectly definite atmospheric condition as to the direction and force of the wind, the inequalities of distant temperatures, the relative altitudes and thicknesses of distant clouds, and the consecutive modifications of these conditions. We have no longer to do with personal and local experience, but with an analytical description of a small number of characteristics, easy to comprehend and applicable at every locality throughout the globe.

My very extensive memoir is at present in press and will appear in "Annales" of the Central Meteorological Bureau of France, 1898. The object of this short note is to point out to physicists the fact that the questions of general meteorology belong to their domain and merit their attention, and that however difficult they may appear they are not unsolvable.

The types shown in the five sections of the accompanying diagram differ only as to the thickness and the elevation of the cloudy layers. In the neighborhood of the ground the variation of temperature with latitude is inverse to that which obtains in the upper levels; the ring of mixture extends around the earth on parallels of latitude nearly uniformly at the same level as that of the two zones throughout their whole extent; generally it rises to the upper part of the atmosphere on its polar side, and on its equatorial side descends to the lower atmosphere near the ground.

The more complicated types in which the variation of temperature with latitude has the same sign above and below, but the opposite sign at a medium altitude, are also described in the complete memoir; these give rise to thunderstorms.

CLIMATE AS A CONTROLLING FACTOR IN LONG-DISTANCE TRANSMISSION OF ELECTRICAL ENERGY.

By ALEXANDER G. MCADIE (dated August 27, 1897).

Those of us who have done any experimental work in atmospheric electricity, at a very early period in our experiments, learned the necessity of an almost perfect system of insulation, in dealing with the very high potentials likely to be encountered. In fact, with all our care, there is always a lingering suspicion in examining photographic records, that the running down of the voltage in foggy and damp weather was, in large measure, the consequence of the defective insulation due to a deposit of the moisture. The careful worker will always rigorously and frequently test his insulators. In the material, glass with sulphuric acid, and in the shape of the insulator, we strive to prevent any creeping or leaking of the charge. The Mascart table and suspension insulators which are now to be found in most physical laboratories are excellent and embody the principles upon which the future hightest insulators must be constructed. Since they were designed, however, both mica and quartz have come into commercial use, and it might be interesting to compare insulators made of these materials with the standard Mascart patterns. But even with a good insulator we must watch constantly the hygrometric condition of the air, for the insulation which is